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FROST PROTECTION BY IRRIGATION IN SOUTHERN TEXAS.

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The cultivation of vegetables for the winter and early spring markets has been carried on over southern Texas to some extent for many years, but since large irrigation plants have been put in operation, this industry has, in the last 10 years, been so extended that many farmers now devote their entire time to truck raising. Occasionally in severe winters vegetables that are not protected from killing frosts and freezing temperatures are badly damaged or destroyed.

Many methods of protecting crops from frost and injurious temperatures have been tried over southern Texas. Some methods, used elsewhere to advantage, have proven too expensive in this section of the country. Smudging by pot-fires, so highly praised in other sections of the United States and some foreign countries, is very expensive and has not proven a success in portions of southern Texas, because the brisk to high winds that generally accompany cold waves and freezing temperatures carry the smoke and heat away from the crops; however, this method is very beneficial in calm weather.

On account of the prevailing local conditions, a covering with hay or cloth, or flooding the land with water where possible, have proven to be the most successful and least expensive methods of protecting small crops in southern Texas from frost or injurious temperatures.

Frost never forms unless the condensation of the aqueous vapor in the atmosphere takes place with temperatures at, or below, the freezing point. Plants lose their heat principally by radiation and convection; this takes place more rapidly in some localities than others, depending somewhat upon the character and condition of the soil, the topography of the country, and the degree of cloudiness. Any method of preventing the radiation and convection of heat from plants during unusually cold weather will prove beneficial in protecting crops. The spraying of plants and trees with a fine spray of water on a frosty morning before sunrise is beneficial. Apparently this water is absorbed by the outside cells of the frozen plants and buds of the trees as they thaw, thus preventing the bursting of the cells and the disorganization of the plant tissues so that the damage by the freeze is greatly reduced.

During the winter of 1904-5 the writer observed the effects of a severe freeze on cabbage in the vicinity of Corpus Christi, Tex. The cabbage heads were about 8 inches in diameter when a cold wave with a minimum temperature of 18°F. was experienced. The heads were frozen through, there being ice at the center. The sky remained cloudy during the cold wave, and when the temperature rose above freezing a light rain commenced falling. The plants thawed out slowly and where earth was thrown up so as to cover the stalk, the cabbage almost fully recovered from the effects of the freeze. Where the stalk was not hilled or covered with dirt it became diseased in the center and soon decayed, withered and fell, making it necessary to immediately gather these plants for use, before the disintegration extended from the stalk into the cabbage head. These cabbages were

large enough for the market at that time. Those plants that had earth around the stalks continued to grow and in a short time showed practically no serious effects of the freeze.

At other times when in Weather Bureau shelters temperatures of 22° to 28°F. were experienced with a clear sky, it was observed that soon after the sun commenced shining and the temperature rose above freezing cabbage and other vegetables were damaged and small plants occasionally killed, but when it rained as the temperature rose to freezing or above, the damage to truck was generally slight if any.

When irrigation was put into operation the truck gardeners near Corpus Christi, Tex., who were prepared to irrigate were advised to flood their fields when killing frosts or freezing temperatures were expected. A number of the truck growers made arrangements to get the forecasts over the long-distance telephone at their own expense when freezing weather was forecasted. They depended upon the advice of the Weather Bureau official who telephoned the warnings as to the necessity of flooding their fields. They also observed from actual experience that when cabbage and other hardy vegetables were flooded with water during periods of freezing temperature, then their crops, though sometimes damaged, could generally be saved during the coldest weather experienced in that section of the country. Even when ice formed around the plants, especially cabbage, these appeared to thaw out gradually. The plant cells were generally left in normal condition and the crops would continue to grow after the plants and cabbage heads had been frozen.

Another advantage resulting from the protection of vegetables by flooding in southern Texas is that since the earth is always warm prior to the approach of the cold waves, hence the water being warmed by conduction from below cools slowly, and as a result the air surrounding plants that are flooded is not quite so cold as in fields which are not flooded with water.

Cold waves over southern Texas rarely last more than one or two days. Owing to the short duration of freezing temperatures, cabbage and other hardy vegetables have not thus far been damaged by the water remaining on the fields where drainage is well provided. When tender plants are left under water several days they will not recover from the effects of being flooded, hence fields should never be flooded until near the approach of injurious temperatures. As soon as the air temperature rises above freezing the fields should be drained to prevent damage to plants from being under water too long. Cabbage and other garden truck, where raised in the winter months, should be cultivated so that the stalks will be covered with dirt if possible. This makes a ridge or hill around the plants, protecting them to some extent from the cold. When so cultivated it is an aid to quick drainage and recovery from the effects of flooding, as the first soil to be drained is that which immediately surrounds the plants.

When the results obtained by flooding crops during freezing weather are compared with the lowest temperatures experienced, the value of protection of crops by irrigation can be ascertained. To enable such a comparison, tables showing the lowest temperatures over southern Texas, with remarks of truck growers who saved their crops by protection, are here given.

The following table shows the monthly and annual minimum, or lowest, temperatures in degrees (Fahren-

heit) at Corpus Christi, Tex., since the station was established, February 1, 1887, to 1913, inclusive:

TABLE 1.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.
1887.....	33	46	57	70	73	72	59	49	33	24	16	16	16
1888.....	16	43	41	57	44	66	73	71	63	50	39	37	16
1889.....	34	42	45	58	56	69	74	70	56	54	40	46	34
1890.....	32	30	28	50	58	65	70	74	55	50	42	35	28
1891.....	33	34	37	46	64	64	70	65	66	51	34	36	33
1892.....	25	48	31	49	60	64	72	71	65	45	42	27	25
1893.....	34	33	41	56	57	70	73	69	70	53	40	36	33
1894.....	24	29	38	58	63	64	70	70	67	42	42	36	24
1895.....	32	16	38	51	58	70	76	73	62	53	38	28	16
1896.....	34	39	42	53	65	68	72	70	58	56	30	32	30
1897.....	22	32	47	52	60	65	72	73	58	55	43	29	22
1898.....	36	41	40	51	58	64	72	74	69	47	38	28	28
1899.....	28	11	42	44	66	71	75	75	65	55	41	36	11
1900.....	29	29	41	47	61	70	72	72	75	54	38	38	29
1901.....	32	33	42	52	60	67	74	74	60	62	48	20	20
1902.....	28	35	44	53	63	72	76	73	61	59	41	36	28
1903.....	35	27	42	52	51	59	68	70	54	50	37	39	27
1904.....	29	32	38	50	61	68	70	73	70	52	37	33	29
1905.....	26	18	48	49	63	70	65	73	70	48	46	32	18
1906.....	30	30	37	53	58	68	72	71	68	52	33	36	30
1907.....	36	38	48	47	47	65	71	73	67	61	37	44	36
1908.....	35	38	48	48	53	74	68	70	58	49	39	40	35
1909.....	24	27	41	48	56	69	75	73	54	53	46	30	24
1910.....	30	26	46	54	61	68	73	73	70	48	48	44	26
1911.....	21	37	45	55	57	72	71	73	72	47	29	35	21
1912.....	22	25	40	53	60	65	74	75	61	54	39	36	22
1913.....	27	35	37	48	63	71	72	74	59	45	46	41	27

The following table gives the monthly and annual minimum, or lowest, temperatures at Fort Brown or Brownsville, Tex., from November 1, 1892, to 1913, inclusive, except during months when no records were kept:

TABLE 2.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.	*F.
1892.....	27	33	42	50	62	70	65	67	52	42	29	29	29
1893.....	31	27	39	57	64	64	63	69	66	44	46	37	37
1894.....	32	22	39	48	41	59	57	68	69	56	40	27	22
1895.....	38	35	40	45	67	66	65	63	51	56	30	30	30
1896.....	38	35	40	45	67	66	65	63	51	56	30	30	30
1897.....	38	35	40	45	67	66	65	63	51	56	30	30	30
1898.....	38	35	40	45	67	66	65	63	51	56	30	30	30
1899.....	33	12	45	49	69	67	71	73	60	38	25	12	12
1900.....	37	27	40	47	64	71	65	71	63	48	37	25	25
1901.....	37	26	38	47	61	69	68	68	58	53	37	25	25
1902.....	37	26	38	47	61	69	68	68	58	53	37	25	25
1903.....	37	26	38	47	61	69	68	68	58	53	37	25	25
1904.....	32	36	41	51	58	68	69	67	71	50	41	39	32
1905.....	30	22	48	54	63	68	68	72	68	52	51	33	22
1906.....	30	32	40	58	61	69	70	72	68	52	51	33	22
1907.....	35	35	46	49	59	72	68	69	58	48	40	38	35
1908.....	28	29	40	46	61	67	72	71	51	53	54	33	28
1909.....	30	32	46	46	58	64	71	70	62	44	42	37	30
1910.....	21	38	49	57	58	68	70	69	71	44	27	34	21
1911.....	24	27	40	52	56	64	71	70	63	53	39	34	24
1912.....	30	37	44	55	65	69	69	70	56	45	44	34	30
1913.....	30	37	44	55	65	69	69	70	56	45	44	34	30

The following statement is by Mr. Charles E. Coleman, of Corpus Christi, Tex., one of the leading vegetable growers and heaviest shippers of produce by express in

southwest Texas, relative to protection of cabbage from freezing temperatures by flooding. Mr. Coleman says:

During the winter of 1910-11, I purchased in the field near Corpus Christi some 60 acres of growing cabbage, all under irrigation. A few days after purchasing these crops and while you were with the United States Weather Bureau at this point you advised me one evening that a cold wave would reach Corpus Christi the following day, and advised me to flood my cabbage fields with water from our irrigation ditches. I immediately telephoned my men and had them flood the fields, as suggested, and, as a result, the growing cabbage was very little damaged, although the thermometer went as low as 17°F., which was unusually cold for this section of the country.

As a result of our saving our cabbage, it was sold at a good price, while cabbage growing in other fields that were not irrigated suffered very severely from the freeze, and in a great many instances was entirely killed, thereby entailing a heavy loss upon the grower.

I would have sustained the same loss in my crops had not you advised me promptly of the coming cold wave, and for this reason we are warm advocates of the Government system of weather warnings.

Mr. C. H. Pease, a prominent citizen of Raymondville, Tex., who has used heaters burning crude oil for the protection of orange trees only, says:

During the winter of 1911-12, I used heaters in a small orchard of oranges. The freeze on Thanksgiving was the first time that I used them. The trees heated did not drop a leaf, while those adjoining that were not protected lost all of their leaves and were frozen back. The second week in January, 1912, I again heated one night, with the result that the trees did not drop a leaf, while those not protected were frozen to the ground. The protected trees bore lightly during the season of 1912, and in 1913 they bore heavily, yielding two boxes excellent fruit to the tree. Those unprotected that froze to the ground came up, as they were banked with earth, and this year, 1914, they are also heavily loaded with fruit. The heated trees were planted thickly, about 200 to the acre. I used crude oil burners, one pan to the tree. I had a thermometer in the center of one of the trees, and it never fell below 28° during the night. No frost formed on the trees. Outside of the protected area a thermometer registered 19°F. The night was calm, making it unusually favorable for this method of protection. With a high wind, I believe a wind break with wood fires on the north, would supplement the oil fires.

Mr. M. L. Gilliland, of this place, covered an acre of watermelons with a conical frost protector and saved them from a late frost. From this acre he loaded the first car of watermelons in this place, and received \$336 for the carload. He had some 15 acres that were not protected, and from them he sold \$900 worth of melons. The acre protected yielded him about five times as much revenue per acre as the land not covered.

A large number of farmers are investing in these protectors, preparatory to planting watermelons early next spring.

Mr. Marcus Philips, a leading citizen of Riviera, Tex., in writing of protection of citrus fruit trees says:

The forecasts of frost and freezing temperatures that I received from the United States Weather Bureau for several years, through you at Corpus Christi, Tex., were of great value as shown by the results of fruit trees protected.

Citrus fruit trees at Riviera were protected by the use of canvas and a small lantern. The canvas was made like a wagon cover, but long enough to reach around the tree, was drawn together at the top and bottom, and the lighted lantern placed inside at the base of the tree. This afforded absolute protection and did no damage. The lowest temperature recorded was 16°F., on February 18, 1910.

Citrus trees were also protected by covering with covered boxes and filling the spaces between the foliage and branches in the boxes with loose hay. This was also effective.

Nearly all the unprotected citrus trees during temperatures of 20° or lower, were severely injured or killed.

Very little protection was given to vegetables in this locality. In a few instances watermelons and beets were plowed, drawing the dirt very close and almost covering the plants, which usually saved a large per cent of the crop.